Clinical Update

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Lasers in Periodontics: An Overview

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Introduction

Lasers, an acronym for light amplification by stimulated emission of radiation, are named according to their active medium.[1,3] Stimulated emission is a process that takes place within the active medium as postulated by Albert Einstein, resulting in a characteristic wavelength.[1,2]

Lasers can interact with their target material by either being absorbed, reflected, transmitted, or scattered.[2] Absorbed light energy gets converted to heat and can lead to warming, coagulation, or excision and incision of the target tissue.[2] Although the wavelength of the laser is the primary determinant of how much energy is absorbed by the target tissue, optical properties of the tissue, such as pigmentation, water content, and mineral content, can also influence the extent of energy absorbed.[2] Furthermore, lasers are able to deliver their energy by way of two waveforms, continuous and pulsed.[3] Continuous wave lasers deliver large amounts of energy in an uninterrupted steady stream potentially resulting in increased heat production. Pulsed wave lasers usually deliver smaller amounts of energy in interrupted bursts, thereby countering the build up of heat in the surrounding tissues.[3] Due to the myriad of factors involved with lasers and specific tissue responses, numerous lasers have been developed.

The purpose of this clinical update is to provide a brief overview of the most common lasers marketed for periodontal procedures. In addition, their effects on soft tissues, hard tissues, bacteria, local factors, and their effectiveness in the non-surgical treatment of periodontal disease will be discussed.

Table 1: Common Lasers Used in Periodontal Procedures

Active Medium	Wavelength	Absorption	Uses	Precautions
Carbon Dioxide (CO2)	10,600 nm	Water	Soft tissue procedures*	Potential for delayed wound healing, carbon residue
Erbium:Yttrium-Aluminum-Garnet (Er:YAG)	2,940 nm	Water, Hydroxyapatite	Soft tissue procedures* and use on hard tissues**	Must use with water spray
Nedymum:Yttrium-Aluminum-Garnet (Nd:YAG)	1064 nm	Pigmented tissue	Soft tissue procedures*	Greatest depth of penetration, can melt or alter surfaces of implants
Indium-Gallium-Arsenide-Posphide (Diode)	635-980 nm	Pigmented tissue	Soft tissue procedures*	Can penetrate soft tissues to a depth of 3 mm

* soft tissue incision/ablation, frenectomy, gingivectomy, gingival troughing, esthetic contouring of the gingiva, treatment of oral ulcers, deepithelization of reflected flaps, removal of granulation tissue, stage two exposure of implants, gingival depigmentation, and coagulation of free gingival graft donor sites.
**Cleared by FDA in 1997 for use on enamel, cementum, and bone.
Table adapted from Cobb 2006[2] and Dederich 2004[3].

Soft Tissue Effects

Most purported advantages of lasers center around improved wound healing. Laser usage has been reported to decrease swelling, edema, and scarring resulting in pain reduction and faster healing when compared to scalpel surgery. A review of the literature, however, reports conflicting results regarding some of these advantages. Most studies that have examined the healing rates of lasers have included the CO_2, the Nd:YAG, and diode lasers. A study comparing the Nd:YAG and CO_2 lasers on wound healing post irradiation, revealed that the CO_2 laser-induced wounds healed significantly faster than the Nd:YAG laser-induced wounds on oral, oropharyngeal, and laryngeal mucosa.[4] Both lasers, however, healed slower than wounds created by the scalpel.[3,4] Other studies, evaluating soft tissue healing after the use of a CO_2 laser in comparison to the conventional scalpel wound, have concluded that the CO_2 laser results in slower soft tissue healing overall,[4,5] or slower during the first 14 days.[6] In addition, the use of diode lasers have not shown any evidence of accelerated healing following a gingivectomy or periodontal flap surgery.[7,8]

Hard Tissue Effects

Few studies actually measure the real-time bone surface temperatures while a laser is irradiating the overlying soft tissues. One study, however, examined the temperature increases of bone while a 810nm diode laser was used in a continuous wave mode within periodontal pockets of rats and found that after nine seconds of irradiation, 10°C to 11°C increases in bone temperature could be recorded.[9] A 10°C increase may result in bone necrosis. Spencer et al[10] demonstrated that pulsed Nd:YAG irradiation of bone significantly increased temperature when compared to continuous wave CO_2 laser irradiation. This demonstrates how the optical properties of the target tissue can dramatically affect the clinical outcome, as the wavelength of a CO_2 laser is best absorbed by water and has little effect on bone. When evaluating the healing of osteotomy defects, the CO_2 and Nd:YAG lasers have shown delayed osseous healing[11,12] while the use of the Er:YAG laser has shown healing similar to the use of rotary burs.[13,14] The delayed healing of laser-induced bone incisions can be a result of the severe collateral tissue damage which occurs.

The use of lasers to modify cementum and dentin has yielded conflicting data. Several in vitro studies have demonstrated that the use of the Nd:YAG laser can produce root surface alterations including charring, melting, and crater formation.[15,16,17] Clinically, this could result in the impaired ability of the flap to reattach. The Nd:YAG laser has also been shown to decrease cellular viability of human periodontal ligament fibroblasts, even at pulsed irradiation using low energy densities.[18] The CO_2 laser has also shown an effect on fibroblasts. Fayad et al.[19] reported a total lack of fibroblast attachment to laser treated surfaces. On the other hand, Pant et al.[20] and Crespi et al.[21] demonstrated that after laser treatment of surfaces, increased in vitro attachment of fibroblasts was noted in comparison to those surfaces treated by conventional chemical conditioning agents or scaling and root planing alone. The Er:YAG laser has shown some promise in being able to remove dental calculus[22,23], diseased cementum[24], and endotoxin.[25] However, the use of the water spray is paramount to avoid causing heat-induced surface alterations and pulpal damage, realizing that the cooling effect would likely be reduced while treating deeper periodontal pockets.

Effects on Bacteria and Local Factors

The effectiveness of lasers on the removal of calculus and the reduction of subgingival pathogenic bacteria has been reported in the literature with conflicting results. An vivo study assessing the efficacy of the Nd:YAG laser at reducing pathogenic bacteria showed decreases in *P. gingivalis* (Pg), *P. intermedia*, and *A. aggregatibacter*, however after 7 days recolonization of the laser-irradiated root surfaces occurred.[26] Another study comparing the use of the Nd:YAG laser in conjunction to

scaling and root planing versus scaling and root planing alone found that the addition of the laser therapy resulted in a greater reduction of *T. forsythia*, Pg, and *T. denticola*. However, microbial rebound did occur in both treatment modalities, approaching baseline levels at 10 weeks.[27] The diode laser has shown to have an additive effect on reducing subgingival bacteria in periodontal pockets greater than 4 mm when used in conjunction with scaling and root planing.[28] The CO_2 laser has also been shown to produce root surfaces devoid of bacteria when used after scaling and root planing.[29] A study by Eberhard et al. compared the removal of calculus by an Er:YAG laser to scaling and root planing. Their results showed that the laser treated root surfaces were only 68.4% calculus free in contrast to the scaled and root planed root surfaces which were 94% calculus free.[30]

Treatment of Chronic Periodontitis

Treatment of chronic periodontitis by a laser is founded on the principle of subgingival curettage, and thus is considered non-surgical in nature. The soft tissue lasers that have been marketed for subgingival curettage include the Nd:YAG, the diode, and the CO_2.[2]

Recently, a statement was issued by the American Academy of Periodontology (AAP) in regards to lasers being used in the non-surgical treatment of inflammatory periodontal disease.[31] The AAP mentioned three reported benefits specifically: laser mediated sulcular and/or pocket debridement (laser curettage), reduction of subgingival bacterial levels (pocket sterilization), and scaling and root planing. The AAP concluded that laser curettage provides little to no benefit beyond scaling and root planing alone. With regards to pocket sterilization, the AAP stated that the ability of lasers to reduce subgingival bacterial loads was unpredictable and inconsistent. According to the AAP, the use of lasers for scaling and root planing yields conflicting results with some studies showing a marginal benefit while others showing no benefit when compared to scaling and root planing alone. For more information: http://www.perio.org/resources-products/pdf/laser-efficacy-statement.pdf

Conclusion

Lasers can have many advantages including a virtually bloodless field and post-surgical course, a lack of mechanical trauma to the tissues, tissue surface sterilization, minimal or no suturing, reduced swelling and edema, reduced scarring, and microsurgical capabilities.[2,3] However, lasers also have many disadvantages such as slower wound healing, slower surgical time, relatively high cost, more armamentarium, and the need for training.[1,2] Some lasers have also been shown to melt and alter surfaces of implants and can impede a histological diagnosis of tissues post-biopsy. When using soft tissue lasers, one should always be cognizant of the potential of thermal damage to the underlying structures. Therefore, if a clinician is choosing to implement a laser in their office for periodontal procedures, it is imperative that they be aware of the many different lasers on the market, their characteristics, their uses, and their advantages and disadvantages. Recent evidence suggests that lasers may not be more effective than conventional treatment in regards to the treatment of inflammatory periodontal disease.

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